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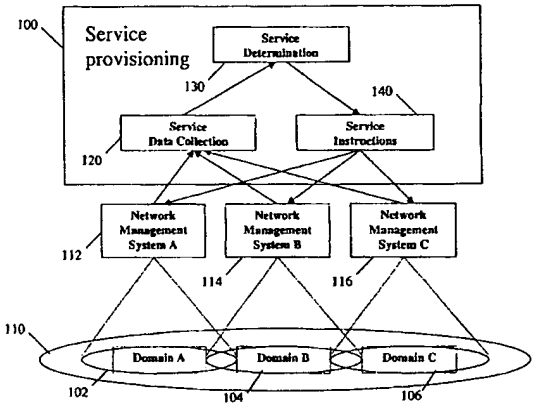
(54) Title: METHOD AND APPARATUS FOR AUTOMATED SERVICE PROVISIONING ACROSS MULTIPLE NETWORKING TECHNOLOGIES



(57) Abstract: In a system of data, voice, application and video services that depend on multiple, interconnected network technologies, a management system suited for a particular networking technology manages each separate technology domain. A higher-level cross-domain system performs the task of automated service provisioning including (i) interacting with the services providers and consumers to determine the services being contracted for (130); (ii) collecting data from the multiple management systems (120); and (iii) sending instruction (140) to the multiple management systems (112, 114, 116) in order to provision the required service and the associated quality across the multiple networking technologies. The individual management systems (112, 114, 116) of the invention collect service data from their respective technology domains (110) and provide it to a service collection function. This data is then utilized by the service determination function to determine what service instruction should be sent from a service instruction function to the management systems for implementation in their respective technology domains.

WO 02/06973 A1

Method and Apparatus for Automated Service Provisioning Across Multiple Networking Technologies

Related Applications

This application claims priority to United States Provisional Application Ser. No. 60/217,969, filed July 13, 2000.

Field of the invention

The invention relates to management of communications networks and, in particular, to provisioning of network services.

Background

Traditionally, there have been two manners of provisioning network services that depend upon multiple interconnected networking technologies (e.g. optical networks, ATM networks, customer premise LANs, etc.). These are (i) on-site installation and configuration and (ii) drop-ship and swivel chair provisioning. In on-site installation and configuration, service providers literally truck in devices to a customer's site, install the devices, and then adjust the devices on site in order to begin provision of the service. In drop-ship and swivel chair provisioning, service providers ship pre-adjusted collections of devices to a customer site and then connect to the devices with device-specific element managers in order to fine-tune parameters and begin provision of the service. Both of these traditional methods are non-automated. As a result, they are expensive and error-prone, requiring the coordination and use of many different individuals and resources.

Automated service definition, monitoring, and control are now possible for several individual networking technologies. These automated functions are typically built on top of the existing management systems that manage that specific kind of networking technology. Aprisma Management Technologies' Spectrum® Management System is an example of an existing management

system that has these capabilities. Utilizing these functions, automated service provisioning is now becoming available. However, automated provisioning of services with these tools is currently limited to services that are dependent on only a single underlying networking technology.

What has been needed, therefore, is a consolidated, automated service provisioning tool that can provide such functions as service templates, service contracts (SLAs), service activation and modification, service inventory, service monitoring and control (reactive and proactive), and service billing for provisioning services across multiple interconnected underlying networking technologies.

Objects of the invention

The object of the present invention is to provide automated provisioning of network and associated services that depend upon multiple interconnected networking technologies.

Summary

In the present invention, service provisioning and monitoring are performed from a single console and over multiple interconnected underlying networking technologies. The invention is an automated, consolidated service provisioning tool that provides such service provisioning functions as service templates, service contracts, service activation and modification, service inventory, service monitoring and control, and service billing. In the invention, a management system suited for a particular networking technology manages each separate technology domain within a multi-technology network. A higher-level cross-domain system performs the task of automated service provisioning, providing three functions: (i) interacting with service providers and consumers to determine the services being contracted for; (ii) collecting data from the multiple management systems; and (iii) sending instructions to the multiple management systems in order to provision the required service and associated quality across the multiple, interconnected networking technologies.

The individual technology management systems of the invention collect service data from their respective networking technology domains and provide it to a service data collection function. This data is then utilized by a service determination function to determine what service instructions should be sent from a service instruction function to the management systems for implementation in their respective networking technology domains. In a preferred embodiment, the service instructions take the form of configuration instructions and data that are implemented by network managers on individual devices in their respective technology domains.

The automated service provisioning system of the invention may alternatively be built on top of an existing multi-domain management system, such as an enterprise management system. In this embodiment, the service provisioning system interacts solely with the multi-domain management system, giving it instructions to configure devices in certain ways in order to set up the required multi-domain service. The network management system or systems, systems manager or managers, and application manager or managers that manage the individual networking technology domains are then themselves managed by the multi-domain management system.

A service provider utilizes the service provisioning system of the invention to create service templates that are used in the negotiation of a service contract between the consumer and the service provider. If the contracted service is compatible with existing services, then the relevant portions of the configuration dataset and service instructions may be sent directly to the individual managers for each domain. Alternatively, the configuration dataset and other instructions for activating the service are sent to a multi-domain manager and from there to the individual managers for each domain.

The service provider also uses the automated service provisioning system to provide service reports and billing, to finalize service contracts and to maintain service inventory. After the service contract is finalized, the service provider makes use of the service activation function. The consumer utilizes the

service reports and billing function, the finalize service contract function, and the service activation function. An optional operation support system may also interact with the automated service provisioning system of the invention for service reports and billing, service activation and service monitoring and control.

The enabling technology for automated service provisioning is the same technology that permits operation, administration and maintenance of the underlying networking technologies. One key feature for enabling automated service provisioning is configuration management, which typically includes such tasks as identifying, controlling and monitoring the "managed devices" that make up a communications network and associated systems. In particular, configuration management permits the establishment, supervision, and release of channels from a network perspective. In the preferred embodiment, policy-based configuration management is utilized.

Brief Description of the Drawings

Fig. 1 is a block diagram of an example implementation of an apparatus for automated service provisioning across multiple interconnected networking technologies according to the present invention;

Fig. 2 illustrates the operation of an embodiment of the method for automated service provisioning across multiple interconnected networking technologies of the present invention;

Fig. 3 illustrates a use case model of the consumer and service provider requirements for service provisioning;

Fig. 4 is the conceptual architecture of an alternate embodiment of the apparatus of the present invention, utilizing an enterprise management system for cross-domain management;

Fig. 5 illustrates the conceptual differences between the automated method of the invention and one of the traditional non-automated methods of performing the function of the invention;

Fig. 6 illustrates an example of multiple interconnected networking technologies across which services may be provisioned by use of the present invention;

Fig. 7 depicts the data stores required by a typical embodiment of the invention;

Fig. 8 depicts an example network with which the present invention may be utilized;

Fig. 9 is an example embodiment of the automated service provisioning system of the invention, designed to provision services across the example network of Fig. 8;

Fig. 10 is a schematic illustration depicting how a policy-based configuration management system may be utilized in implementing the automated service provisioning apparatus of the present invention; and

Fig. 11 is a schematic illustration of one embodiment of a policy-based device configuration management system that may be used in implementing the automated service provisioning apparatus of the invention.

Detailed Description

The present invention allows service provisioning and monitoring to be performed from a single console and over multiple interconnected underlying networking technologies. It is an automated, consolidated service provisioning tool that provides such functions as service templates, service contracts (including service level agreements), service activation and modification, service inventory, service monitoring and control (reactive and proactive), and service billing. It has tight integration with underlying element and network management systems. The invention may be used alone, or in conjunction with one or more of the traditional non-automated methods of service provisioning.

In the present invention, a management system suited for a particular networking technology manages each separate technology domain within a multi-domain network with respect to fault, configuration, accounting, performance, and security (FCAPS) management. A higher-level system,

called a cross-domain management system, performs the task of automated service provisioning. This cross-domain system performs three functions: (i) interacts with service providers and consumers to determine the services being contracted for; (ii) collects data from the multiple management systems; and (iii) sends instructions to the multiple management systems in order to provision the required service and associated quality across the multiple, interconnected networking technologies.

Fig. 1 is a block diagram illustrating an example implementation of the apparatus of the present invention. As can be seen in Fig. 1, the automated service provisioning function of the invention 100 is comprised of three parts that perform the functions (i) – (iii) described above. Service determination function 130 interacts with service providers and consumers to determine the services being contracted for; service data collection function 120 collects data from the multiple network management systems; and service instruction function 140 sends instructions to the multiple network management systems in order to provision the required service and associated quality across the multiple, interconnected networking technologies. These functions are typically implemented as one or more software applications, using any convenient and suitable method known in the art.

As shown in Fig. 1, in the present invention separate technology-specific management systems are utilized to manage individual networking technology domains (e.g. optical networks, ATM networks, LANS, etc.) in the enterprise 110. In the embodiment of Fig. 1, networking technology domain A 102 is managed by network management system A 112, networking technology domain B 104 is managed by network management system B 114, and networking technology domain C 106 is managed by network management system C 116. The network management system components 112, 114, and 116 may be filled by Aprisma Spectrum, Hewlett-Packard (HP) OpenView, or any other compatible management system, device or agent capable of managing the associated networking technology domain. Alternatively, the invention may

utilize a collection of element management systems instead of the network management systems 112, 114, and 116 of the example embodiment.

Network management system A 112, network management system B 114, and network management system C 116 collect service data from respective networking technology domains A, 102, B 104, and C 106 and make it available to service data collection function 120. This data is then utilized by service determination function 130 to determine what service instructions should be sent from service instruction function 140 to network management systems A 112, B 114, and C 116 for implementation in respective networking technology domains A 102, B 104, and C 106. In a preferred embodiment of the invention, the service instructions take the form of configuration instructions and data that are implemented by network managers 112, 114, and 116 at the individual devices in respective technology domains 102, 104, and 106.

A high-level operational flowchart of service provisioning according to one aspect of the invention is shown in Fig. 2. In Fig. 2, the service provider utilizes the service provisioning system of the invention to create service templates 210 that are used in the negotiation of a service contract 220 between the consumer and the service provider. The service contract typically would include such things as the type of service being contracted for, expected usage amounts, duration, charges, penalties for violation of the contract, other special polices, and any quality of service guarantees. The negotiated service contract would therefore be expected to encompass all the factors included in a typical service level agreement (SLA).

If the contracted service is compatible with existing services 230, then the relevant portions of the configuration dataset and service instructions may be sent by the service provisioning function directly to the individual network managers 240 for each domain. Alternatively, the configuration dataset and other instructions for activating the service may be sent by the service function to a multi-domain manager and from there to the individual network managers

for each domain. If the contracted service is found to not be compatible with existing services 230, then the service contract must be renegotiated 220.

Fig. 3 illustrates a use case model of the functional requirements for the present invention, showing the ways in which service providers and consumers may use the system. As shown in Fig. 3, the automated service provisioning system of the invention 300 provides a number of functions to the service provider 302 and/or consumer 304. The service provider 302 uses the automated service provisioning system 300 to create service templates 310, to provide service reports and billing 312, to finalize service contracts 314 and to maintain service inventory 316. After the service contract is finalized 314, the service provider makes use of the service activation function 320.

The consumer 304 utilizes the service reports and billing function 312, the finalize service contract function 314, and the service activation function 320. Also shown in Fig. 3 is an optional OSS (operation support system) 340 that interacts with the automated service provisioning system 300 of the invention for service reports and billing 312, service activation 320 and service monitoring and control 350.

Fig. 4 illustrates how the automated service provisioning system of the invention may alternatively be built on top of an existing multi-domain management system, such as an enterprise management system. In this embodiment, the service provisioning system interacts solely with the multi-domain management system, giving it the instructions to configure devices in certain ways in order to set up the required multi-domain service. In the embodiment shown in Fig. 4, network management system or systems 410, systems manager or managers 420, and application manager or managers 430 are themselves managed by enterprise management system 440. The various underlying management systems 410, 420 and 430 may be any of the many such management systems known in the art that are capable of being managed by an enterprise management system. Enterprise management system 440 may be the Aprisma Spectrum Enterprise Manager or any other management system

known in the art that is capable of managing the various underlying management systems 410, 420, and 430.

As shown in Fig. 4, a helpdesk 450 and automated service provisioning system 460 are built on top of the enterprise management system 440. Service provisioning system 460 is used for the creation and processing of service templates, negotiation of service parameters, maintenance of service inventory, creation of service reports and billing, and service activation instructions. Configuration instructions and data are sent from service provisioning system 460 to enterprise management system 440 which processes it and then sends configuration instructions and data to the appropriate underlying management systems 410, 420, and/or 430 in order to set up the requested multi-domain service.

Fig. 5 illustrates the conceptual differences between the automated method of the invention and the traditional non-automated "swivel-chair" method of performing the function of the invention. In the "swivel-chair" method 510, service providers operate device-specific elements with a collection of element management systems. The dotted lines in Fig. 5 indicate "managed scope" and the horizontal lines indicate the divisions between the network and service management level 520, the element management level 530, and the element level 540. It can be seen that "swivel-chair" method 510 includes an intermediary set of element management systems 550 (indicated by black nodes) between the network management system 560 and the "bare" network elements 570. The automated service provisioning system of the invention 580 has only a network management system 560 and the bare elements 570; the set of element management systems 550 seen in "swivel-chair" method 510 does not exist in the automated system 580. Thus, the dependence on multiple element management systems that is seen when the traditional method is used can be eliminated by use of the invention.

Fig. 1 illustrated how the management systems of the present invention each manage individual networking technology domains. The example embodiment in Fig. 6 shows three such domains: a customer premises network

610, an ATM network 620, and an optical backbone 614. These are just three examples of the many networking technologies across which services may be provisioned by use of the present invention. In this embodiment, the individual elements in each of domains 610, 612, and 614 are managed by appropriate device managers 620. The device managers 620 within each domain are themselves managed by a domain-specific network management system 630. Service provisioning is then achieved with cross-domain management techniques 640, such as the previously described use of an enterprise manager or any other means of multi-domain management.

Fig. 7 depicts the data stores required by a typical implementation of the invention. As shown in Fig. 1 and again in Fig. 7, the enterprise 710 is comprised of multiple technology domains 720, 722, and 724. Each domain 720, 722, and 724 is managed by an appropriate network manager, management system, or agent 730, 732, 734. Each manager 730, 732, or 734 has an associated operational database 740, 742, or 744 containing "unscrubbed" data 750 that is collected at the source by the manager or an associated monitoring agent. Examples of monitoring agents include, but are not limited to, Spectrum enterprise agents, WinWatch system agents, Patrol application agents, NetScout RMON traffic agents, and special purpose data collection agents.

The data from operational databases 740,742, and 744 is "scrubbed" and then collected in a data warehouse 760 (sometimes called a data mart), from whence it is used in the automated service provisioning system of the invention 770 for the creation of service templates, negotiation of service contracts, production of service reports, service billing, and service planning. Typical data scrubbing actions include (1) replacing a garbage value with a null, (2) collapsing duplicated data, and (3) filtering out irrelevant data. The data warehouse 760 is typically implemented in a commercial database system such as Oracle or Microsoft SQL Server. Many data warehouses or data marts include reporting facilities and generic algorithmic methods for analyzing the stored data, such as Crystal reports and data-mining algorithms, that may be

useful for the performance of some of the service provisioning functions of the present invention.

As an example, the current invention may be used to provision services for a multi-domain network comprised of a multi-wavelength optical network (dense wavelength optical network) that is interconnected with an ATM network at each end. This example therefore provides a specific example of automated service provisioning across two different kinds of interconnected networking technologies (ATM and optical networks). This example has been selected because, while the industry is currently in the midst of developing integrated, cross-domain management that includes single wavelength optical networks, edge data processing and management for dense wavelength optical networks has been lagging behind. The industry is just now developing edge devices and management techniques for dense wavelength optical networks and has yet to begin tackling the problem of integrated cross-domain management. The present invention therefore provides a way to bridge this gap for the automated service provisioning function.

A typical dense wavelength optical network is shown in Fig. 8, utilizing typical generic optical devices. In Fig. 8, the optical terminal multiplexers (OTMX) 810, 850 and optical cross-connect devices (OXC) 830 perform signal regeneration, multiplexing and demultiplexing functions. OTMX 810 also performs the electronic/optical conversion at the interface between ATM space 850 and optical space 860 on the electronic signal coming from ATM node 870. OTMX 840 performs the corresponding optical/electronic conversion as the signal is sent to ATM node 880. The optical line amplifiers (OLA) 820 perform only a signal regeneration function. As noted, at either end of the optical network is an ATM node (870, 880). Service provisioning across this network obviously must therefore be able to accommodate both the optical and ATM networking devices.

Fig. 9 is an example embodiment of the automated service provisioning system of the invention, as designed to provision services across the example network of Fig. 8. As shown in Fig. 9, optical network 902 is managed by

optical management system 904, ATM network A 912 is managed by ATM management system A 914, and ATM network B 922 is managed by ATM management system B 924. The network management system components 904, 914, and 924 may be filled by any management system or device capable of managing the associated network. Optical management system 904, ATM management system A 914, and ATM management system B 924 collect service data from respective networks 902, 912, and 922 and provide it to service data collection function 930 of service provisioning apparatus 900. This data is then utilized by service determination function 940 to determine what configuration instructions and data should be sent from service instruction function 950 to management systems 904, 914, and 924 for implementation in respective networks 902, 912, and 922.

The following steps are development steps by which the current invention may be constructed for service provisioning across an optical network portion of a multiple interconnected networking technology network:

1. Element development
2. Element-style management
3. Fault and Configuration Management
4. Network-style management
5. Service Provisioning for optical networks
6. Cross-domain network management
7. Cross-domain service provisioning

It is understood that these steps apply to service provisioning across the optical network of the example embodiment discussed herein and that similar development steps would be applied to each type of networking technology across which services are to be provisioned.

The enabling technology for automated service provisioning is the same technology that permits operation, administration and maintenance (OAM) of the underlying networking technologies. One key feature of the preferred embodiment of the invention is configuration management. Configuration management typically includes such tasks as identifying, controlling and

monitoring the "managed devices" that make up a communications network. A managed device is any device that can be modeled in a network management system, such as the Aprisma Management Technologies Spectrum Network Management System. The managed devices include not only hardware devices such as personal computers, workstations, hubs and routers, but also software applications.

In particular, configuration management permits the establishment, supervision, and release of channels from a network perspective. Some form of configuration management is therefore generally useful for automated service provisioning. In the preferred embodiment, policy-based configuration management is utilized. Figs. 10 and 11 illustrate aspects of the use of policy-based configuration management for automated service provisioning.

Fig. 10 depicts the way in which policy-based configuration management may be employed for automated service provisioning. The policy-based configuration manager monitors and controls the configuration of network devices with respect to a prescribed policy. The application will typically modify configurations when needed, including, for example, when a device is added to the network and switched on, when network traffic becomes overstressed, and when an administrator wishes to perform a spot check on the network configuration. As employed in the present invention, the configuration manager is typically utilized to modify device configurations when services are initially provisioned or the service contract for an existing service is altered. A preferred embodiment of the invention utilizes Aprisma Management Technologies' Spectrum Network Management Platform and the Spectrum Configuration Management System, but other network managers and configuration managers having the required capabilities would be suitable for use in the invention.

As shown in Fig. 10, live network 1010 communicates with a network management system 1020 via communication link 1022. Network management system 1020 in turn communicates via communication link 1024 with a policy-based configuration management (PCM) system 1030. Network management

system 1020 monitors live network 1010 and gathers information about the managed devices in the network 1010 for use in the management and configuration of the network 1010. Network management system 1020 exchanges this information with the configuration management system 1030 for the performance of a large number of tasks needed for service provisioning including: creation and editing of configuration management records, logging of configuration management changes, capturing existing configuration management records, loading new configuration management records, verification of configuration management records, configuration management status and history reporting, event-triggered configuration, configuration scheduling, enforcement of configuration policies, and adjudication of policy conflicts.

Device configuration management in communications networks generally includes the tasks of keeping an inventory of network devices, knowing/verifying the configuration of each device, resetting or updating configurations as the need arises, and scheduling configuration changes. A configuration is a set of particular values of attributes that govern the operational characteristics of a device (e.g., port thresholds, on/off switches, access, security, etc.). Devices that are reconfigured routinely in communications networks are routers, switches, bridges, and hubs. The PCM generally includes an apparatus for defining a domain space, an apparatus for defining configuration records (a rule space), an apparatus for attaching configuration records to elements in the domain space to create configuration policies, and a policy driver for monitoring and enforcing configuration policies.

The elements in the domain space are network devices such as hubs, bridges, routers, and workstations. Domains are constructed in accordance with the organizational principle by which devices are grouped in the network. In general, network devices may be grouped in any way that serves as an aid in understanding and managing the network. Common grouping principles include

grouping with respect to topology, device type, location, managerial domains, and/or the organizational structure of a network enterprise.

Fig. 11 is an illustration of a policy-based configuration management system that may be used in the automated service provisioning apparatus of the invention. As shown in Fig. 11, the configuration policy space 1110 is comprised of domain space 1120 and configuration records 1130. The domain space 1120 and set of configuration records 1130 interact and provide configuration instructions to the policy driver 1140, which is activated by trigger 1150.

The domain space 1120, at the lowest level of abstraction, consists of objects of interest in the application. Objects are the smallest units in the domain space, and they are defined in terms of their attributes. In access management for example, the objects might be transmissions, where the attributes of transmissions are source Internet Protocol (IP) address, destination IP address, and service type. In fault management, objects might be alarms, where the attributes of alarms are alarm severity, device type, and device location. At higher levels of abstraction, objects are grouped into domains. A particular grouping principle depends on the objects of interest in the application and the attributes of the objects. The domains include both objects and other domains, as one domain may be a member of another domain.

The function of the policy driver 1140 is to monitor objects in the domain space 1120 and to enforce configuration policies 1110. The inputs to the policy driver 1140 are the trigger 1150, the structure of domain space 1120, and the set of configuration records 1130 attached to elements in the domain space. The output of the policy driver 1140 is an action space 1160 which is ultimately sent to the live network 1170 or to the network management system 1020 in Fig. 10. The output of the policy driver 1040 may comprise one or more of: a configuration load, a notice of conflicting configurations, a notice of "no action required"; and a report of the state of overall network configuration. These outputs are user-selectable. The policy driver may be triggered by one or more of the following events: a device goes

up or down; a new device is added to the network; the network goes up or down; a scheduler triggers the driver; and a user manually triggers the driver.

Policy driver 1140 therefore operates on action space 1160 to effect live device configurations 1170 and, in particular, to generally bring about enforcement of a policy in the network. Information regarding live device configurations 1170 is then fed back to policy space 1110 for the initiation of further configuration instructions. Actions taken are dependent on the particular application. They may include permission or forbiddance of an operation on the network, the modification of attributes in other objects, the display of a console message, or an entry in a log file.

The present invention may also be utilized as part of integrated Internet Protocol (IP) and telephony management. There are a variety of service offerings and applications hosted by combined Internet Protocol (IP) and telephony networks. The integrated IP and telephony network is becoming increasingly complex, with a corresponding need for interoperable multi-vendor equipment. The need is therefore arising for a single system for provisioning services across the disparate parts of the IP and telephony infrastructure.

The mapping of business requirements to network requirements will shape the success of next-generation converged networks. The urgency for such a platform is growing with the emergence of integrated voice and data technologies such as Voice over IP (VoIP). Clients who are looking to deploy VoIP technologies, IP-based telephone switches (e.g. PBXs), and other voice and data convergence technologies need a means for managing the network infrastructure and provisioning services across it. They also require integrated software solutions that will provide them with the information for calculating the Total Cost of Ownership of this converged network, thereby bridging the gap between business requirements and network requirements.

Service providers such as telecommunications carriers (including incumbent local exchange carriers and competitive local exchange carriers), Internet service providers, national service providers, inter-exchange carriers, cable operators, application service providers, management service providers,

and IT outsourcers are looking for new areas for generating additional revenue. The largest potential is for a single voice and data service offering. However, one of the anticipated problems most commonly associated with the advent of converged voice and data networks is that of developing a single platform for end-to-end management that allows traditional FCAPS management in addition to dynamic service provisioning, monitoring, and accounting. A platform is therefore required that provides integrated management and service provisioning over multiple networking technologies. In particular, such a platform must (i) span across converged networks, (ii) include traditional FCAPS management, and (iii) allow service definition, provisioning, monitoring, and accounting. The present invention provides a unique and efficient way to implement requirement (iii).

As an example of the challenges in developing such a platform, consider telephony PBX management. Currently there are no SNMP management standards for PBXs, and hardware vendors are offering different levels of SNMP support. Service provisioning is typically done manually by network operators, and billing is often a flat monthly fee. Service providers, however, are beginning to look for ways to automate the process. The typical approach to managing this type of hardware is to offer basic SNMP management, and to complement that with a means to invoke a proprietary PBX element manager from the primary SNMP platform. While this solution may work for the short term, clearly it is rather inelegant. A solution is required that provides standards-based management of both IP and telephony equipment from a single management system. The current invention is a necessary part of that solution.

The present invention facilitates the future development of a network management system that not only performs traditional management functions such as fault and configuration management, but also provides automated service provisioning and billing. Consider the optical network used previously as an example. The service offered by an optical network is the allocation of bandwidth to consumers. However, that means that an operator has to set up, maintain, and release optical channels between terminal devices in response to

consumer demands. A management system which utilizes the automated service provisioning system of the present invention would know the theoretical capacity of the optical core, know what consumers have contracted for portions of bandwidth, be able to configure optical devices in order to accommodate changes in consumer demands, and produce bills for consumers. What has been described herein is merely illustrative of the application of the principles of the present invention. Other arrangements, methods, modifications and substitutions by one of ordinary skill in the art are also considered to be within the scope of the present invention, which is not to be limited except by the claims that follow.

CLAIMS

What is claimed is:

1. An apparatus for automated cross-domain service provisioning in a multi-domain communications network comprising, in combination:

a service determination application for identifying one or more services to be provisioned across said multi-domain network;

a service data collection application for collecting data on provisioned services and on the configuration of said multi-domain network; and

a service instruction application for relaying instructions to said multi-domain network for provisioning of the services.

2. The apparatus of claim 1, wherein said service instruction application relays said instructions to a cross-domain management system in said multi-domain network.

3. The apparatus of claim 2, wherein said cross-domain management system relays said instructions to at least one network management system associated with at least one domain in said multi-domain network.

4. The apparatus of claim 1, wherein said service instruction application relays said instructions to at least one network management system associated with at least one domain in said multi-domain network.

5. The apparatus of claim 1, wherein said service instruction application relays said instructions to at least one element manager in said multi-domain network.

6. The apparatus of claim 1, wherein one or more of said relayed instructions are configuration instructions.

7. An apparatus for service provisioning in a multi-domain communications network comprising, in combination:

a cross-domain service provisioning application; and

a cross-domain management application for receiving instructions from said service provisioning application and relaying them to said multi-domain network for provisioning of services.

8. The apparatus of claim 7, wherein said cross-domain management application relays said instructions to at least one network management system associated with at least one domain in said multi-domain network.

9. The apparatus of claim 7, wherein said cross-domain management application relays said instructions to at least one element manager in said multi-domain network.

10. The apparatus of claim 7, wherein one or more of said relayed instructions are configuration instructions.

11. The apparatus of claim 10, further comprising a configuration management system for creating or modifying said relayed instructions.

12. An apparatus for service provisioning in a multi-domain communications network comprising, in combination:

a cross-domain service provisioning application; and

at least one network management application associated with at least one domain in said multi-domain network, for receiving instructions from said service provisioning application and implementing them in said domain for provisioning of services.

13. The apparatus of claim 12, wherein at least one of said network management applications associated with at least one domain in said multi-domain network relays said instructions to at least one element manager in said multi-domain network.

14. The apparatus of claim 12, wherein one or more of said relayed instructions are configuration instructions.

15. The apparatus of claim 14, further comprising a configuration management system for creating or modifying said relayed instructions.

16. A method for automated cross-domain service provisioning in a multi-domain communications network comprising the steps, in combination, of:

automatically deriving one or more instructions for provisioning of contracted services across said multi-domain network; and

relaying said one or more instructions to said multi-domain network.

17. The method of claim 16, further comprising the step of automatically identifying one or more services to be provisioned across said multi-domain network.

18. The method of claim 16, further comprising the step of automatically collecting data on provisioned services and on the configuration of said multi-domain network.

19. The method of claim 17, further comprising the step of automatically collecting data on provisioned services and on the configuration of said multi-domain network.

20. The method of claim 16, wherein said one or more instructions are relayed to a cross-domain management system in said multi-domain network.

21. The method of claim 20, wherein said cross-domain management system relays said instructions to at least one network management system associated with at least one domain in said multi-domain network.

22. The method of claim 20, wherein said cross-domain management system relays said instructions to at least one element manager associated with at least one domain in said multi-domain network.

23. The method of claim 16, wherein said one or more instructions are relayed to at least one network management system associated with at least one domain in said multi-domain network.

24. The method of claim 23, wherein at least one of said network management systems relays said instructions to at least one element manager associated with at least one domain in said multi-domain network.

25. The method of claim 16, wherein said one or more instructions are relayed to at least one element manager in said multi-domain network.

26. The method of claim 16, wherein one or more of said relayed instructions are configuration instructions.

27. The apparatus of claim 1, wherein said service determination function provides for contract negotiation between a service provider and a consumer.

28. The apparatus of claim 7, wherein said cross-domain service provisioning application provides for contract negotiation between a service provider and a consumer.

29. The apparatus of claim 12, wherein said cross-domain service provisioning application provides for contract negotiation between a service provider and a consumer.

30. The method of claim 17, further comprising the step of automatically providing for contract negotiation between a service provider and a consumer.

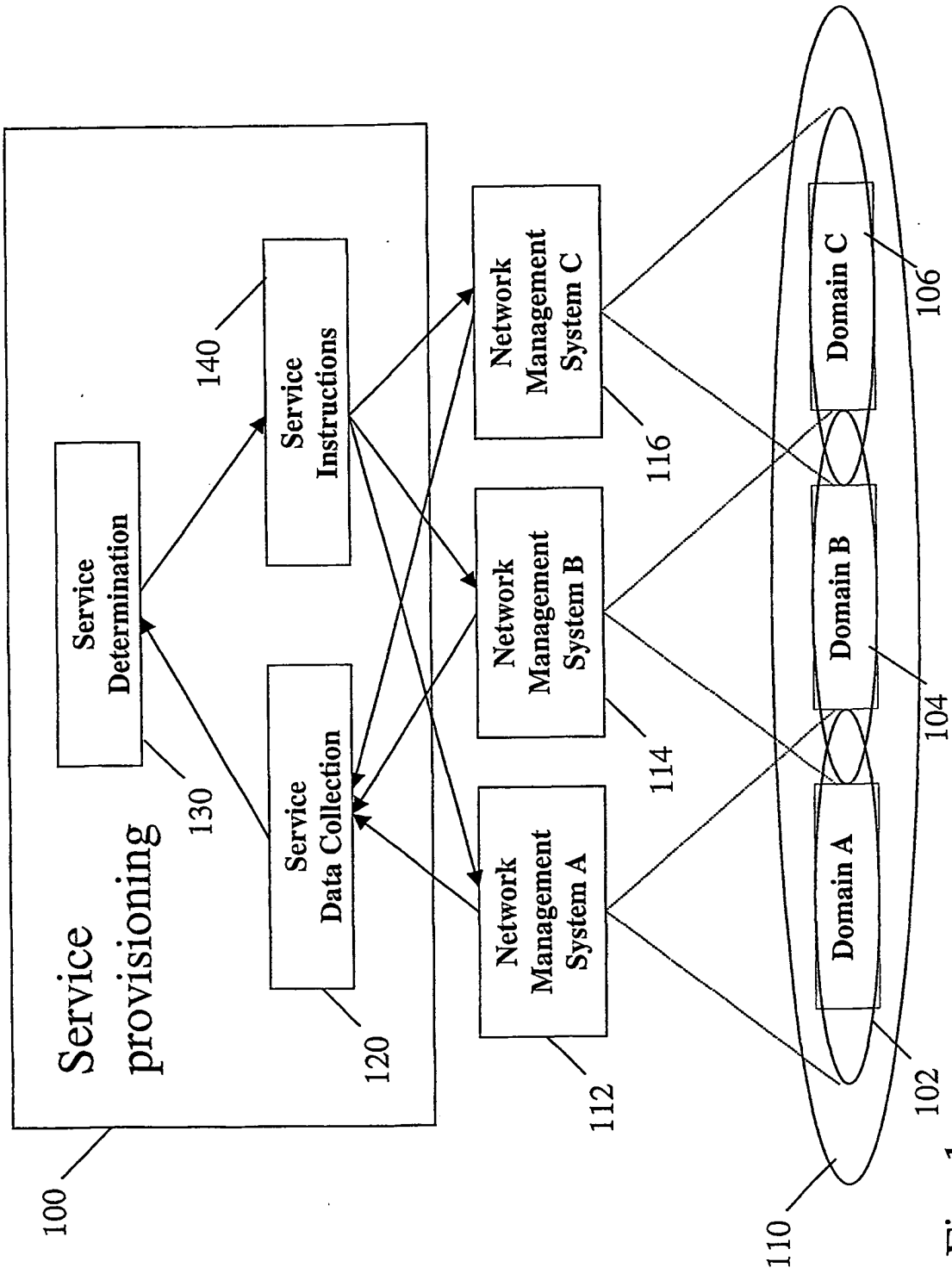

Service provisioning
Service Determination
Service Instructions
Service Data Collection
Network Management System A
Network Management System B
Network Management System C
Domain A
Domain B
Domain C
100
110
102
104
106
112
114
116
120
130
140

Fig. 1

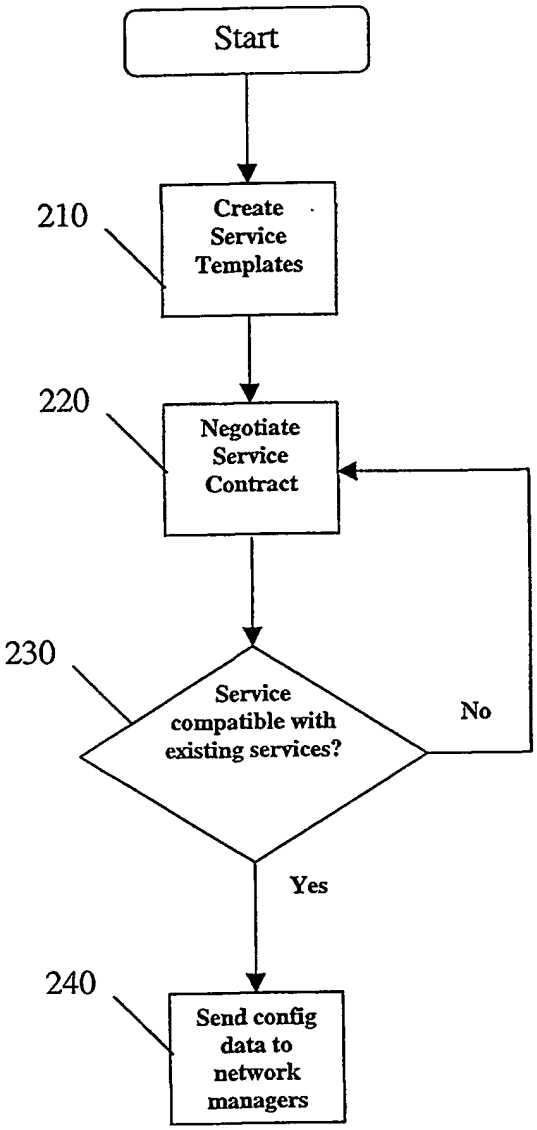

Start
210
Create Service Templates
220
Negotiate Service Contract
230
Service compatible with existing services?
No
Yes
240
Send config data to network managers

Fig. 2

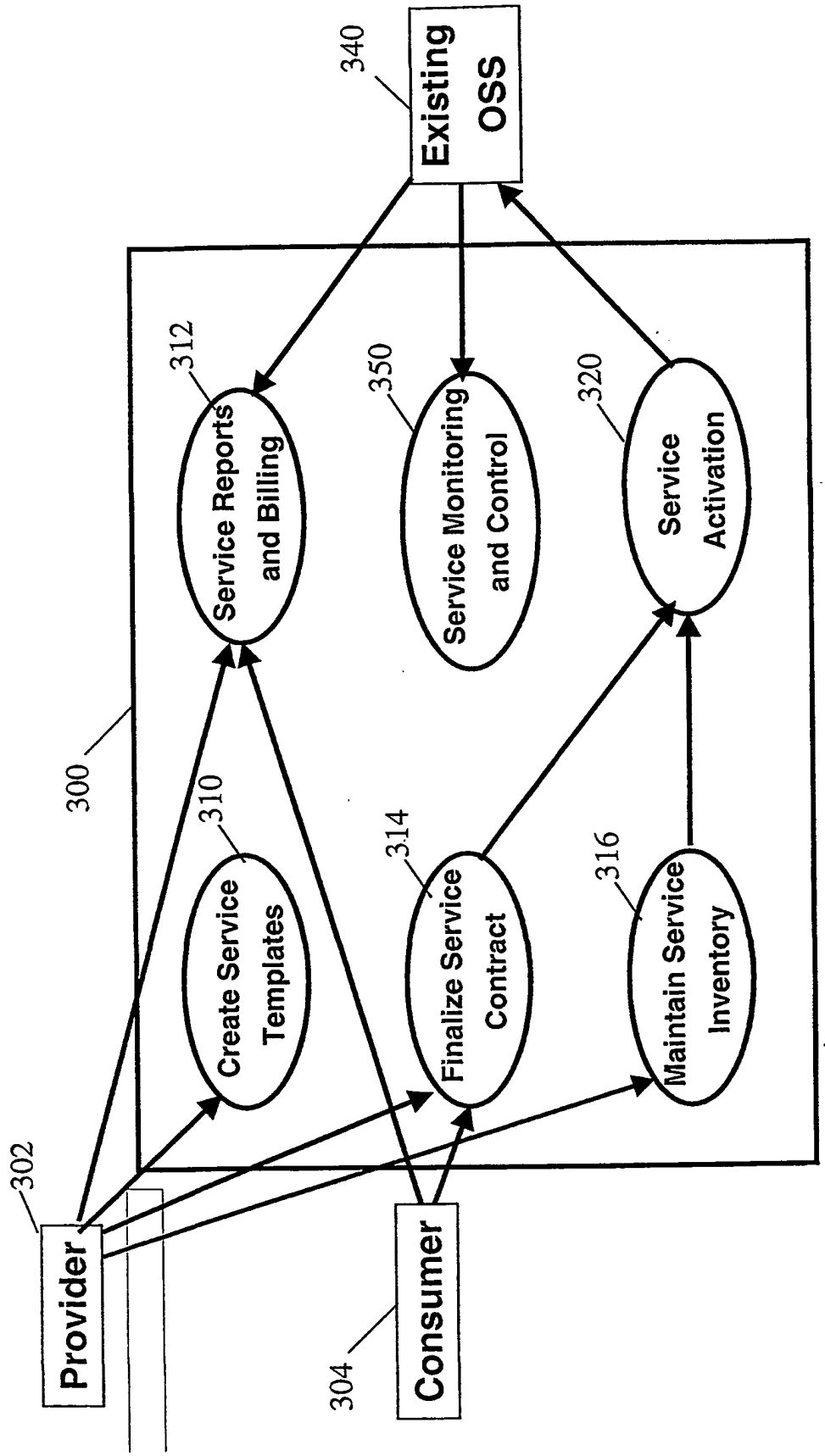

340
Existing OSS
312
Service Reports and Billing
350
Service Monitoring and Control
320
Service Activation
300
310
Create Service Templates
314
Finalize Service Contract
316
Maintain Service Inventory
302
Provider
304
Consumer

Fig. 3

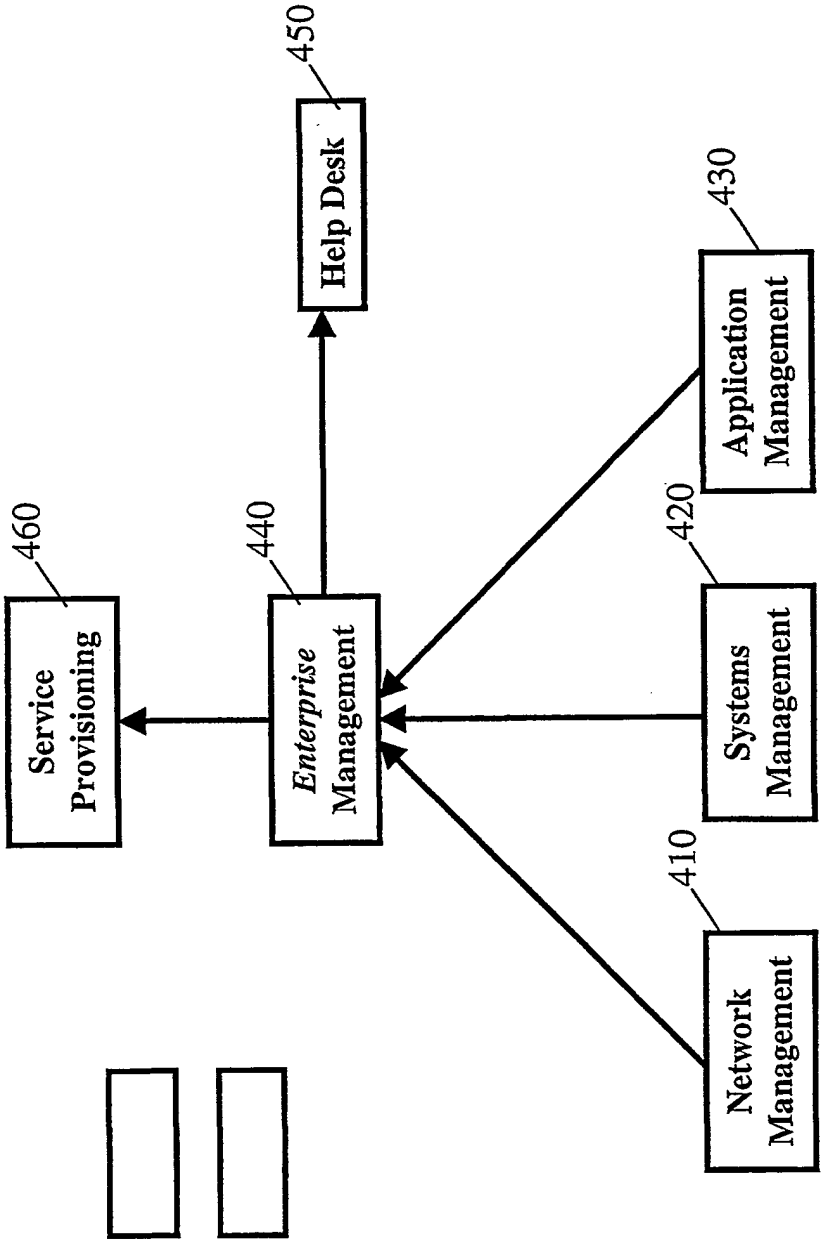

450
Help Desk
430
Application Management
460
Service Provisioning
440
Enterprise Management
420
Systems Management
410
Network Management

Fig. 4

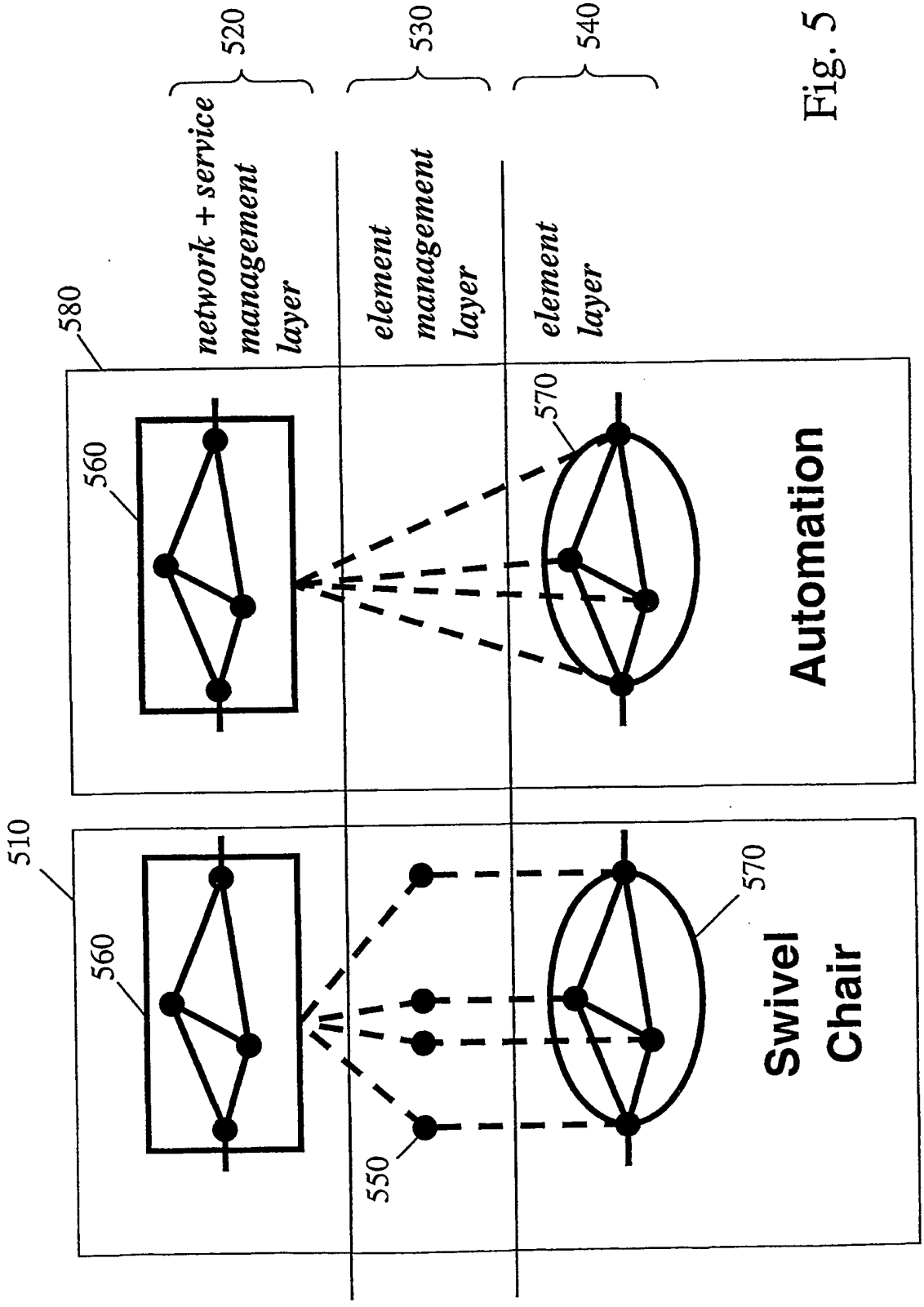

520
530
540
network + service management layer
element management layer
element layer
580
560
570
Automation
510
560
570
550
Swivel Chair

Fig. 5

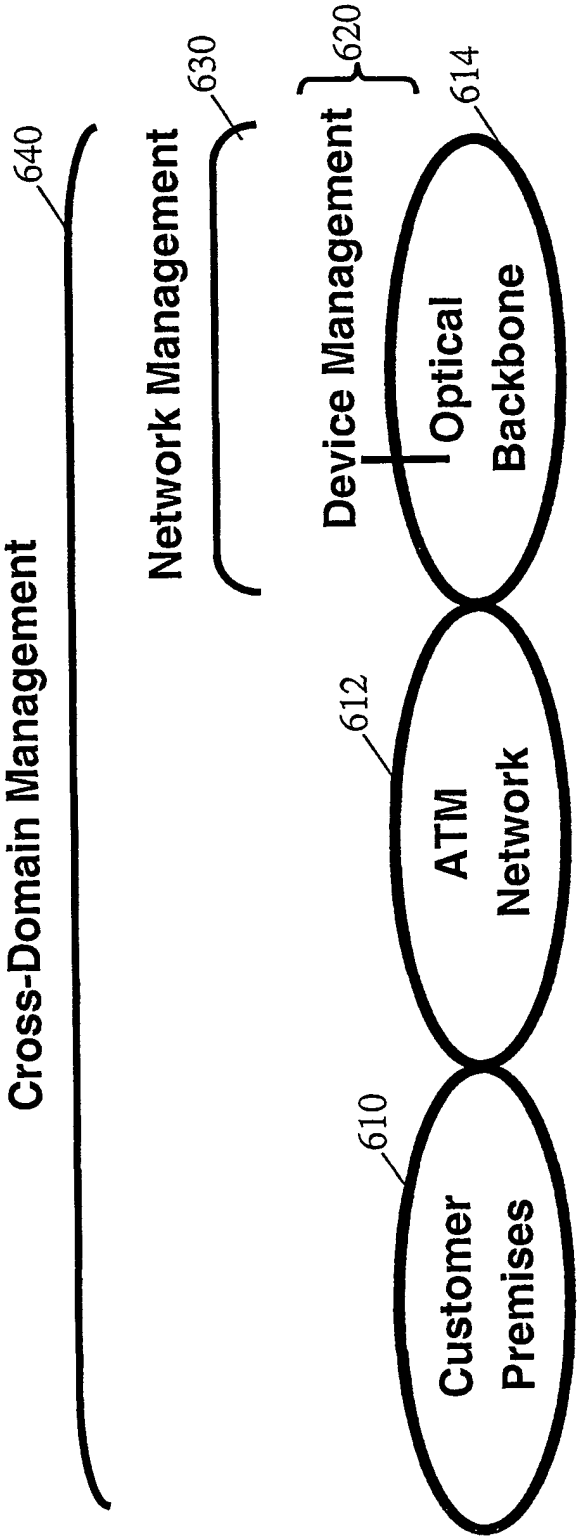

Cross-Domain Management
640
Network Management
630
Device Management
620
Optical Backbone
614
ATM Network
612
Customer Premises
610

Fig. 6

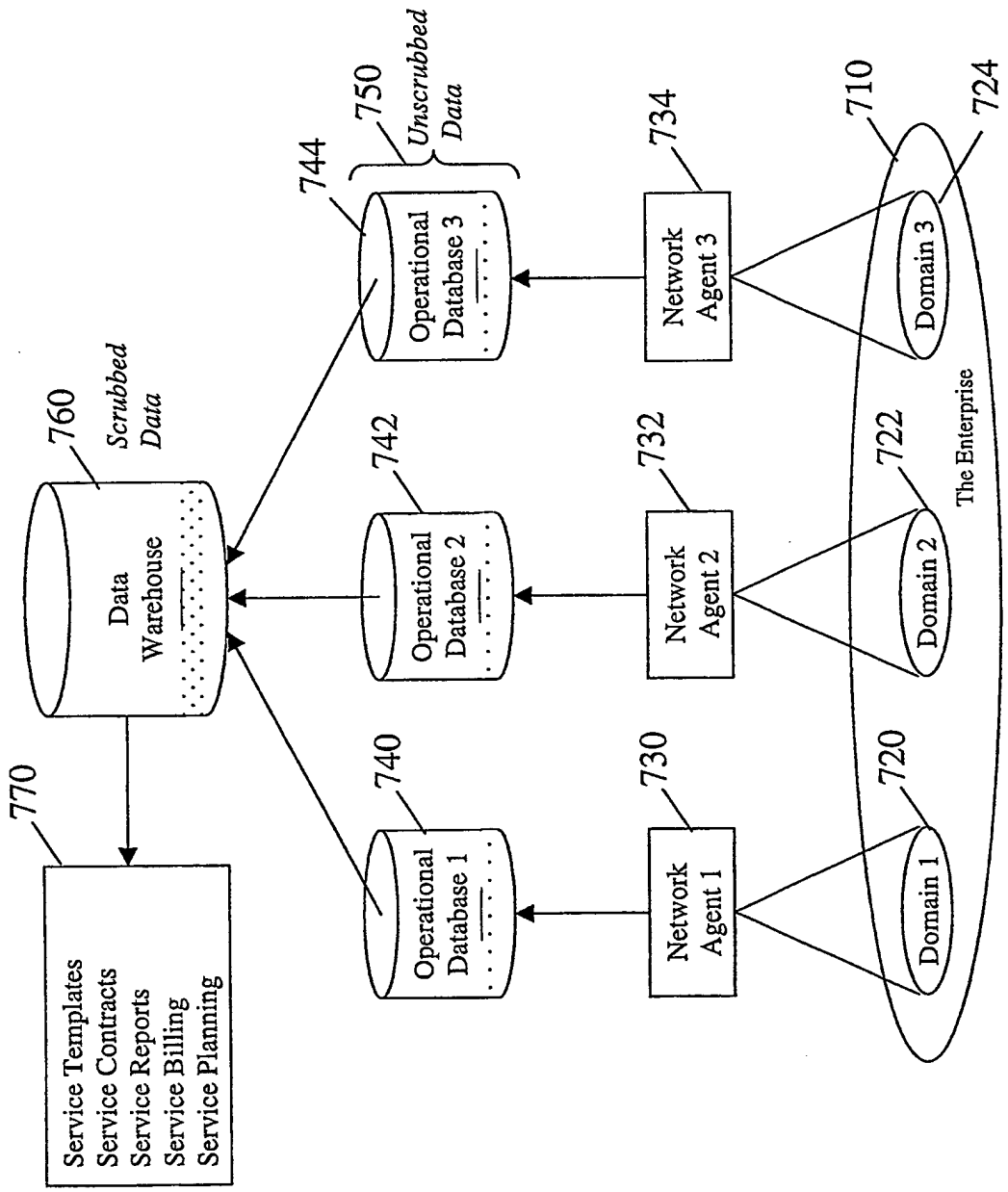

770
Service Templates
Service Contracts
Service Reports
Service Billing
Service Planning
760
Scrubbed Data
Data Warehouse
740
Operational Database 1
742
Operational Database 2
744
750
Unscrubbed Data
Operational Database 3
730
Network Agent 1
732
Network Agent 2
734
Network Agent 3
720
Domain 1
722
Domain 2
724
Domain 3
710
The Enterprise

Fig. 7

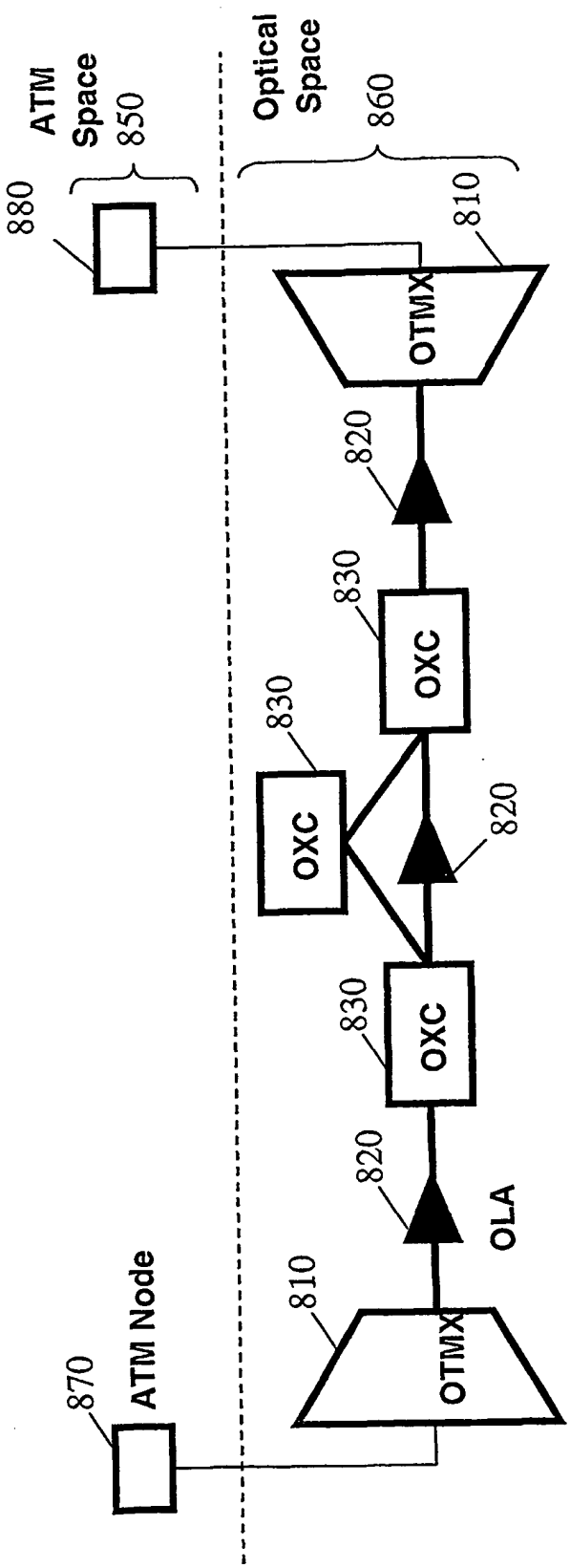

ATM Space
850
Optical Space
860
880
810
OTMX
820
830
OXC
830
OXC
820
830
OXC
820
OLA
810
OTMX
870
ATM Node

Fig. 8

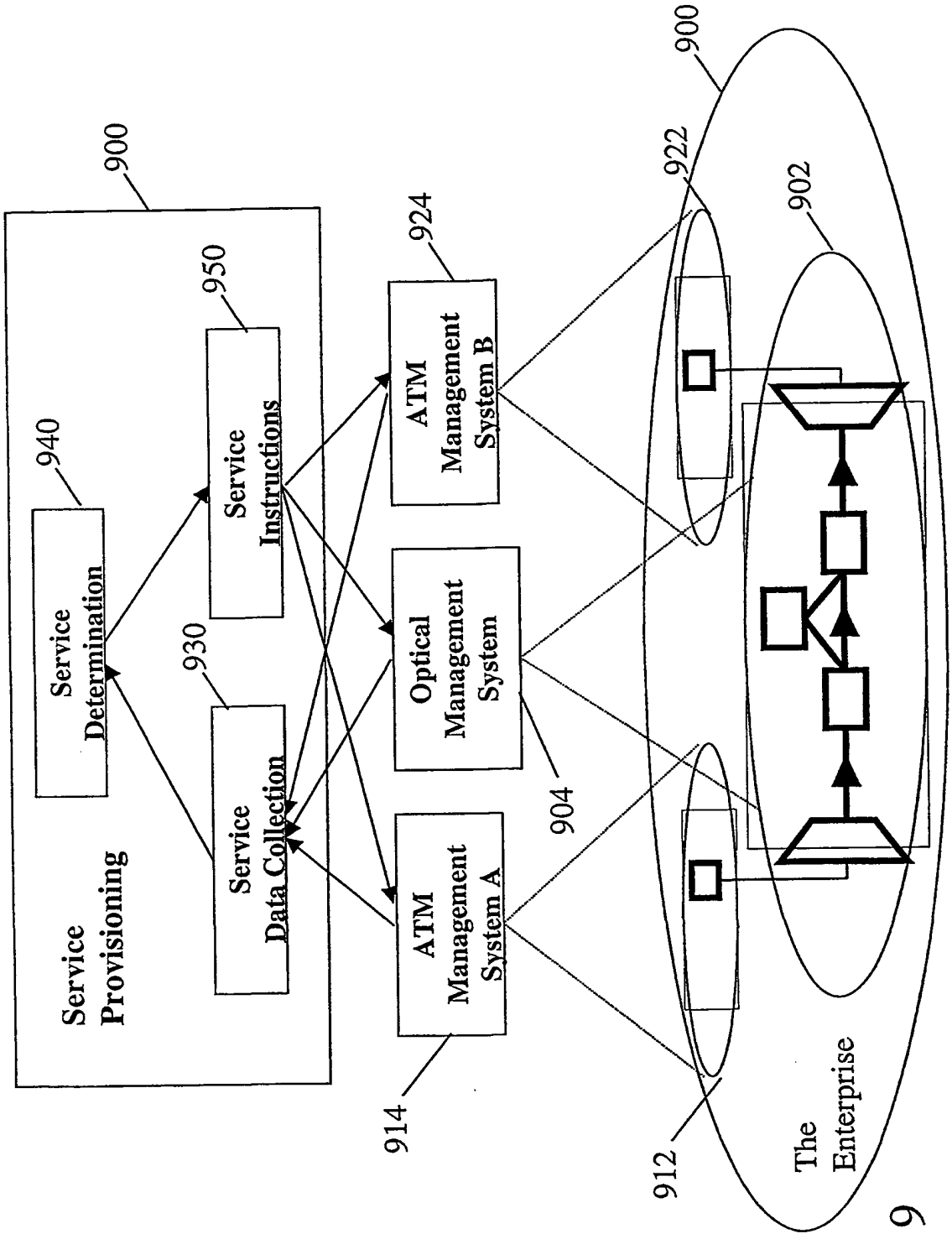

900
Service Provisioning
940
Service Determination
930
Service Data Collection
950
Service Instructions
924
ATM Management System B
Optical Management System
904
ATM Management System A
914
900
922
902
912
The Enterprise

Fig. 9

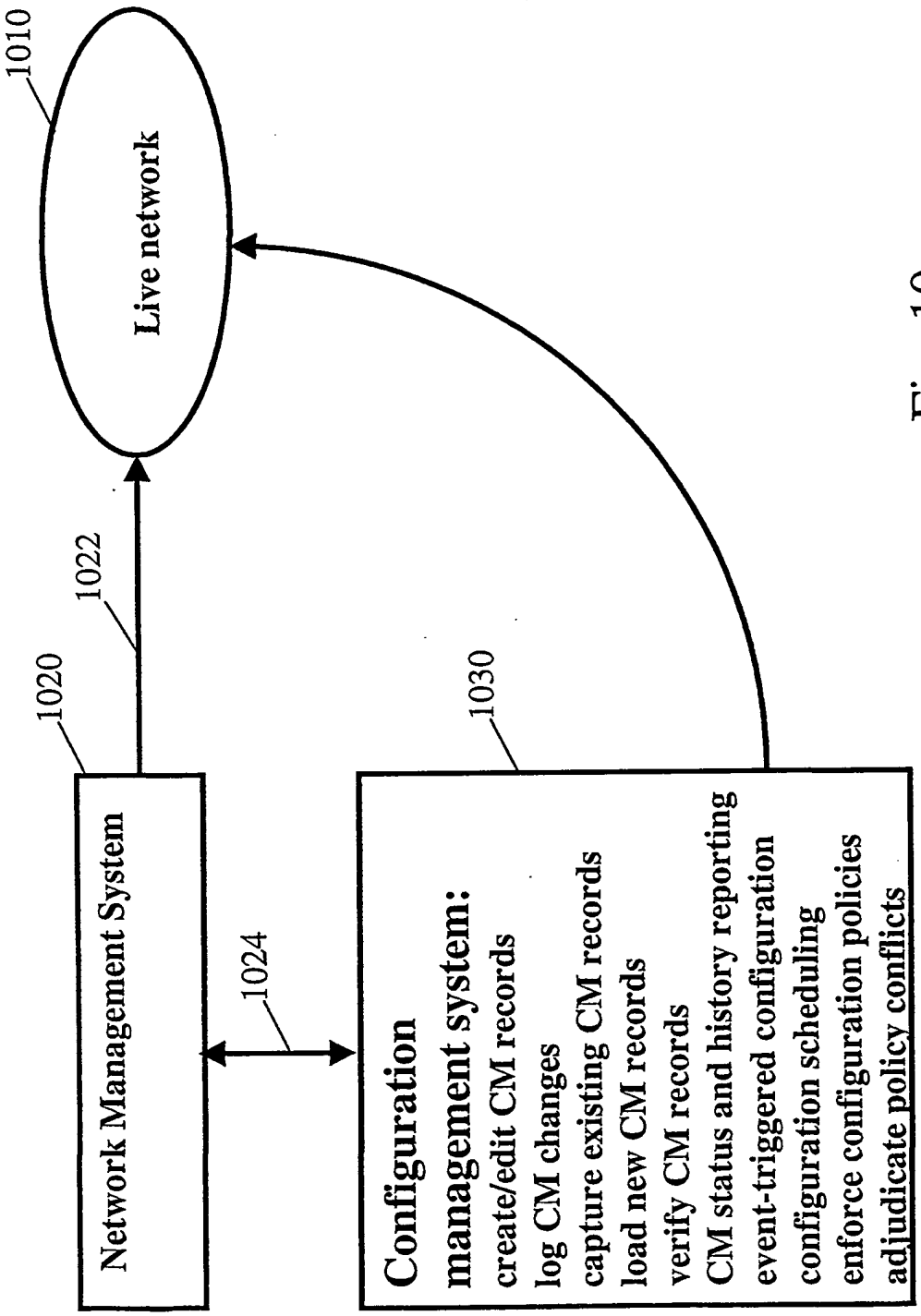

1010
Live network
1022
1020
1030
Network Management System
1024
Configuration management system:
create/edit CM records
log CM changes
capture existing CM records
load new CM records
verify CM records
CM status and history reporting
event-triggered configuration
configuration scheduling
enforce configuration policies
adjudicate policy conflicts

Fig. 10

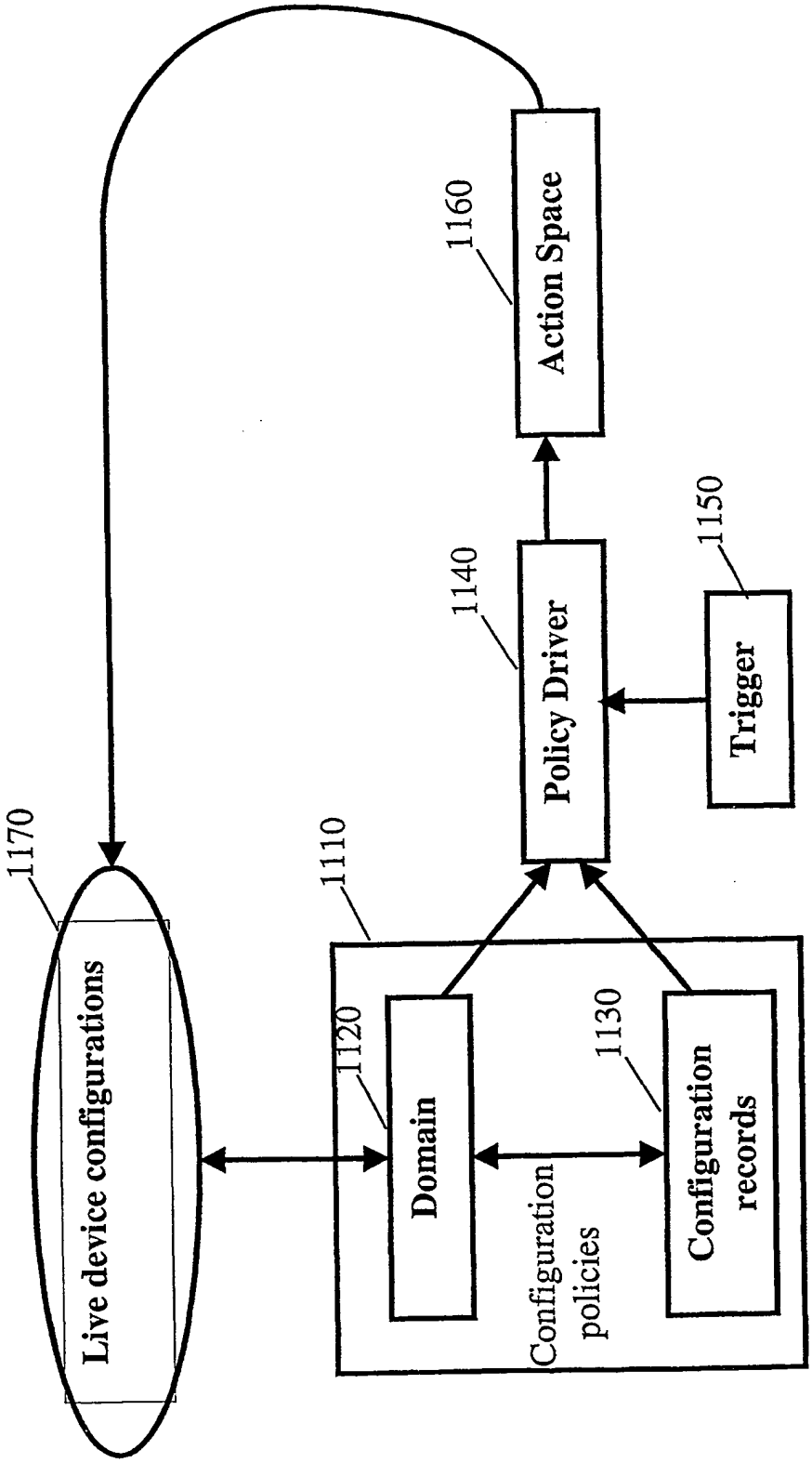

Action Space
1160
Policy Driver
1140
Trigger
1150
1110
Domain
1120
Configuration records
1130
Configuration policies
Live device configurations
1170

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/22109

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G06F 15/173
US CL :709/224, 226

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/231,232; 714/47, 48 709/249

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

IEEE ONLINE
search terms: multi-domain, QOS, network management

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,768,501 A (LEWIS) 16 JUNE 1998 figure 3, 4b, 5, and col. 7-10	1-30
A	US 6,011,780 A (VAMAN et al.) 04 January 2000 ; figure 3, col. 10	1,7,12, 16
A	NAKAMURA et al. A Pricing and Acounting Architecture for QOS Guaranteed Services on a Multi-Domain Network IEEE, 1999 pages 1984-1988; especially pages 1986-1988	1, 7, 12, 16
Y	GALIS Broadband Connectivity Management Services for Multi-Domain ATM and SDH Network, IEEE, 1999, pages 2002-2009, especially pages 2005-2008	1-30

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
26 AUGUST 2001	18 SEP 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer LARRY DONAGHUE James R. Matthews Telephone No. (703) 305-9675

Form PCT/ISA/210 (second sheet) (July 1998)*